the brick-earth of Hoxne may, so far as their *position* affords a clue, be of any age subsequent to the Boulder-clay; but those described by Mr. Prestwich, near Reculver, containing *Cyrena fluminalis*, as well as those of Sangatte, near Calais, would, both by their position and organic contents, seem to fall into the series $x5$; while those at Wissant, described by Mr. Day at page 115 of the 3rd volume of this MAGAZINE, would seem to come nearer to the series $x6$ than any other. "The clay with flints" and "brick-earth" of the Ordnance Surveyors, which occupies a belt of the Chalk country, stretching from near Marlborough to High Wycombe, seems by position to come nearest to the group $x5$.

IV.—SOME OBSERVATIONS ON THE *ZOANTHARIA RUGOSA*.

By GUSTAVE LINDSTRÖM, Ph.M.

[*Continued from the August Number, p.* 361.]

[PLATE XIV.[1]]

THE next operculated species which claims our attention is the *Calceola Gotlandica* of F. Roemer. This species has been removed from the class *Brachiopoda* in a list of the Upper Silurian Brachiopods which I published in 1860. I now give my reasons for so doing (then but briefly indicated).

The shell presents on its exterior two different surfaces, one almost flat and triangular, the other convex (Plate XIV. Figs. 8-11, etc.) The shell has thus the shape of an irregular semi-cone. Close and irregular lines of growth continue interruptedly across these surfaces, and give the flat one, especially, a wrinkled appearance. Rectangular to these lines, or parallel to the longitudinal axis of the shell, are seen extremely delicate and dense striæ. The flat surface is divided in the middle by a longitudinal ridge, which is formed by two or three larger striæ, and by a regular folding outwards of the rim of the calyx. At the rounded angle, where the two different surfaces meet, rootlike processes project, just as in *Goniophyllum*. They often occur in pairs, in some instances on the flat surface, in others (Plate XIV. Fig. 12 and 13) on the convex side. By means of these rootlets they fixed themselves in their young state to *Halycites*, *Favosites*, and other marine bodies. The rootlets are perforated by a very narrow channel, which opens within the calyx. Of all the *Cyathophyllinæ* provided with rootlets none so clearly shows the connection between the channel of the rootlet and the cavity of the calyx as this species. The membrane which lined and secreted the walls of the calyx then formed small branches, which also secreted calcareous matter around themselves and thus formed these rootlike tubes. Their function of attaching the shell ceased when this became of too great a size, they then curve backwards along the flat surface, and terminate on it without opening; consequently, they continued to be formed long after their original

[1] For Plate XIV. see GEOL. MAG., August, Vol. III., p. 356.

function had ceased. During growth the flat surface was elevated above the body on which it originally rested, and became more curved. It is probable that the shell became free when its size became too large in proportion to its points of attachment, as in *Goniophyllum*, or more clearly in *Palæocyclus porpita*. The form of the shell is very variable. The conical shape is seldom regular. The apex is commonly bent towards the convex side. Sometimes the shell is extremely long and narrow (Plate XIV. Fig. 10). In this species, also, the animal reduced its shell and formed a new calyx within the old one (Plate XIV. Fig. 12); this is not, however, to be confounded with the budding as described below.

The opening of the calyx (Plate XIV. Figs. 8 and 11) is semicircular; it is highest at the flat surface. The interior cavity occupies almost three-fourths of the total length in short and broad specimens, and is only a shallow depression in the long shells. The bottom and the walls of the calyx are covered with convex vesiculæ, having a diameter of nearly five millim. The bottom ends in a pit, which continues on the concave wall. In the middle of the flat wall there projects a short and blunt ridge or tooth, homologous with the median septum of the other *Rugosa*. This wall is also covered with narrow, close and indented striæ, parallel to the middle tooth. They are very short, and but few stretch over the vesiculæ before they terminate. When the shell is weathered it seems as if the flat wall were covered with long and narrow rows of small depressed points, instead of these septa of the second order, which are then very obscure. In place of the middle tooth there is seen a shallow groove or depression. The opposite vaulted wall is rather smooth above the vesiculæ; its striæ or septa are distant, low, and more indistinct. The middle one opposite the tooth of the flat wall is more prominent and long, and and reaches to the bottom of the pit. In the angles between both the walls are seen small depressed points or holes, the openings of root-channels. In the young shells (Plate XIV., Fig. 9), the mouth of the calyx is more oblique, the primary septum is more prominent than in the older, it almost reaches to the bottom; the vesiculæ and the lateral septa are indistinct and small, the mouths of the root-channels are very apparent.

In the propagation of this species budding seems to have been of great importance (see Plate XIV. Fig. 14). In thirty-two specimens out of ninety young shells only six, from five to seven millims long, are independently fixed. This attachment of the young to the parent might, at first, seem quite accidental as when shells of other animals (*Syringopora*, *Cyathophylla*, and *Favositidæ*), have grown in the interior cavity of *Calceola*. In such cases, however, it is evident that the shell had lain empty on the bottom of the Upper Silurian sea for a long time after the soft parts of the animal had been decomposed. The operculum has only once been found attached to its shell, and the shells themselves are generally covered with foreign bodies. All idea of accidental attachment in the position of the young shell ceases when it is seen that they are, without exception, fixed in the angles between the flat and the vaulted wall, never on the walls, as

other bodies (Plate XIV. Fig. 14). The apex of the young shell seems actually to shoot forth from the shell-matter of its parent, generally from a groove between two vesiculæ. If the embryo had fixed itself, when the shell became empty after the death of the parent animal, it could not, of course, have penetrated in this manner the mother shell.

The characteristic shape of the *Calceola* is distinct in specimens of a length of three millims. They are connected with the large shell by small rootlets, as well as by their first point of attachment. There is commonly but one bud, seldom one in each corner, more rarely two in each, and only in one instance three on each side. In a specimen of seven millims in length there are already two small buds, they all start from the same point, following, during their course, different directions, generally upwards, but also towards the sides and downwards. Such small shells, as are found attached to other bodies, must have originated in the common manner by the extrusion of free swimming embryo from an ovum. As no aggregate groups of individuals are found, it is probable that the buds having gained a certain size, became free. As to the interior structure of the shell, it consists of basin-shaped layers of oval vesiculæ (Plate XIV. Fig. 18), enclosed by a thin exterior coating, formed by the septa, and consisting of narrow longitudinal striæ.

The operculum of this shell is quite as semicircular as the mouth of the calyx (Plate XIV. Figs. 15 and 16). It has only once been found attached to its shell (Plate XIV. Fig. 13), although it cannot be considered very rare. The outside is marked by faint longitudinal striæ and concentric lines of growth. The nucleus is central and projects in a small point. It is circular, in accordance with the cylindrical form of the smallest shells, which soon become flattened on the side upon which they rest. The operculum is thickest in its centre, and convex on the outside, the interior surface being slightly concave. The uppermost edge, or what may be called the cardinal margin, is much thicker than the very thin or rather sharp side margins. Although thick, there is no such regular area at the cardinal margin, as in *Calceola sandalina*. On the interior side (Plate XIV. Figs. 16 and 17) there is, in the centre, a narrow longitudinal ridge, which disappears almost before it has half reached the inferior margin. It is largest and highest at a distance of two millims from the cardinal margin, where it also ends. Above is a small oval pit, enclosed by two processes, which originate in a common point on the cardinal margin; they also embrace the median ridge. In addition to this, the interior surface is covered with 18–20 striæ on each side of the median ridge, curved in an arch towards it. They are arranged in pairs, but each ray has its distinct starting point at the cardinal margin, parallel to which runs a shallow grove, only interrupted by the oval pit before mentioned.

The operculum in this species was also deciduous, but nevertheless some specimens show that it continued its function during the reduction of the shell. Some opercula are extremely thick, with the interior or youngest stratum far less extensive than the next

exterior ones, so that a very broad cardinal margin, composed of the accumulated strata, projects in an oblique direction above the interior surface. *Calceola Gotlandica*, ranked by F. Roemer among the *Brachiopoda*, is thus found to coincide with the *Rugosa*, in the form of its calyx, in the internal structure of the shell, the rootlets, and its external sculpture.

Of all known forms it seems to me that *C. Gotlandica* most nearly resembles *Calceola Tennesseensis*, F. Roemer.[1] It is true that the rootlets are wanting, but a glance at fig. 1*c.* in Professor Roemer's work, makes it at once evident that the two species have a great affinity. The base of both is covered with vesiculæ, as in *Goniophyllum* and *Cystiphyllum*; the same groove is seen in both on the same side. Instead of the projecting tooth in the middle of the flat wall, there is an elliptical depression, and the cardinal margin is finely crenulated without striæ. But these differences are no doubt produced in the same manner as in *Calceola Gotlandica*, namely, by weathering, so that the tooth, or primary septum, resembles that part in weathered specimens of *Goniophyllum* and *C. Gotlandica*. The shell, to judge by figs. 1 *b*, *e*, *op. cit.*, appears to be quite as irregular in its shape as *C. Gotlandica*. Fig. 1 *a* shows in the centre of the so-called "area," the same ridge as the Gothlandic species, only somewhat larger. The operculum (fig. 1 *d*, *op. cit.*) resembles more that of *C. sandalina*, with its triangular area, with the nucleus close to the cardinal margin.

If we now extend our comparisons to the third known species of the genus *Calceola*, the *C. sandalina*, we find true homologies between it and the two preceding forms. We then only see accidental exterior resemblances with the *Brachiopoda*, amongst which this, as well as the last two mentioned species, have so long been numbered. The regular form of its shell, the similarity of the flat surface with the area of the *Brachiopoda*, and that of the middle ridge thereon with a pseudo-deltidium, may explain its having been retained in that class. Some authors have compared it to *Cyrtina* and *Cyrtia*; others again, in consequence of the "area" of the small valve, with certain *Strophomenidæ*.[2] But this "area" does not form a strictly circumscribed part, nor does it possess peculiar sculpture, characteristic of the species, and different from that on the rest of shell, as in the *Brachiopoda*. On the contrary, this sculpture is quite of the same nature, as on the rest of the surface, the lines of growth continue without interruption on it. The area of the shell is longitudinally sculptured by fine striæ or folds, the centre ones forming the ridge, which is considered by many authors to be homologous with the pseudo-deltidium of the *Brachiopoda*. But this ridge is precisely the same as that met with in almost all specimens of *Zoantharia rugosa*. Besides *Goniophyllum* and *Calceola*, there are a great many *Rugosa* which have a flat surface, somewhat resembling an area, and almost all have such a one during their young state,

[1] Die Silurische Fauna des Westlichen Tennessee, p. 73, Pl. v. figs. 1 a–e.

[2] Eine kleine grobfaltige Abanderung (of *Spirifer trapezoidalis*) nannte Defrance *Calceola heteroclyta*." Quenstedt. Handbuch der Petrefactenkunde, p. 479.

when they adhered to other bodies. In some species (*Calceola, Goniophyllum, Hallia calceoloides*), this flat side remained, while in others it soon became convex, and the shell assumed a cylindrical shape, when it began to raise itself freely above its point of attachment.[1] If we now look at the interior cavity of *Calceola sandalina*, all likeness with the *Brachiopoda* at once ceases. We there again see a groove in the bottom completely coinciding in size and position with that of *Goniophyllum*, other *Calceolæ*, *Omphyma*, etc. Opposite this pit is the middle septum, completely homologous with that in the species just named, and environed by smaller ones. The operculum agrees perfectly with that of *Goniophyllum* and *C. Gotlandica* in its elements, but modified in details. There is a middle ridge on its interior side formed in the same manner, and above it the small oval pit enclosed by two lateral processes, the same striæ on the sides curved towards the middle ridge; indeed, all those points of structure are common to these species. The structure of the shell by no means resembles that so characteristic of the *Brachiopoda*, which is prismatic and often perforated by small pores. It consists of thin, funnel-shaped layers, as in so many of the *Rugosa*. In consequence of all these affinities with the *Z. rugosa* (both with those that are provided with an operculum, and those without), *Calceola sandalina* must be removed from the class *Brachiopoda*, and henceforth considered as one of the *Rugosa*.[2]

But if we again compare *C. sandalina* with *C. Gotlandica* and *Tennesseensis*, we discover more than specific differences, and it seems impossible to retain them any longer in the same genus. *C. sandalina* is distinguished by its more regular shape, and by the absence of all rootlets. The septa are also more regular and complete, the middle septum of the flat wall larger, and the bottom is void of all vesiculæ. It seems, moreover, not to have propagated by means of buds.[3] The figures of *Calceola sandalina*, which have been given in various palæontological works, vary much from my description. This is caused by their having been drawn from weathered specimens. The middle septum is then, as it were, decomposed into its elements leaving two lamellæ with a deep groove between them. In others only the uppermost part of the septum is left, with a depression or groove beneath. This is the case in weathered specimens of *Goniophyllum* and *Calceola sandalina*. The punctated lines between the septa of the second order have, as in the other species, been occasioned by the weathering of the small teeth of the septa. It is easy to prove the existence of a true septum in the middle, and not a

[1] *A Cystiphyllum*, having a shape between a cylinder and a four-sided prism, comes near to the pyramidical form of *Goniophyllum*.

[2] Sir Charles Lyell, in the sixth edition of his Manual, says (p. 537) that some naturalists have lately referred *C. sandalina* to a coral. "They suppose it to be an abnormal form of the order *Z. rugosa*, differing from all other corals in being furnished with a strong operculum." In this opinion I cannot join, because, as I have endeavoured to show, I do not consider *Calceola sandalina*, or the other *Rugosa*, as corals. Neither is the *C. sandalina* an abnormal form of its order.

[3] The best figures of *C. sandalina* are in all probability those seen in Goldfuss's Petrefacta Germaniæ, vol. ii., pl. clxi. fig. 1.

groove, by separating the operculum from a shell, which has been fossilized with it adhering, and has therefore not been exposed to weathering. It is then seen that the smaller septa are finely serrated. The interior structure differs from that of *C. Gotlandica* in not being vesicular. The chief mass of the solid shell consists of very close and thin strata, which end downwards in a very acute apex. The operculum is more regular and has a larger triangular area, and is moreover provided on both sides of the middle ridge with a series of small tooth-like protuberances ("apophyses"), which are totally wanting in *C. Gotlandica*, but are represented in *Goniophyllum* by small irregular teeth on the cardinal area. There is consequently no reason to unite *C. sandalina* with the other two species in one genus, and I therefore propose that *Calceola sandalina* alone should form the genus *Calceola*, that *C. Gotlandica* be the type of a new genus[1] under the name *Rhizophyllum*, while *Calceola Tennesseensis* may perhaps represent another genus very closely allied to the last, but I cannot decide this, as I have not examined any specimens of it. The genus *Calceola*, as now limited, must, no doubt, be placed in the family of the *Cyathophyllinæ* amongst the allied genera; *Goniophyllum* may be placed close to *Omphyma; Rhizophyllum* with its strongly developed vesicular structure and indistinct septa, comes so near to *Cystiphyllum*, that it may be considered as intermediate between the *Cyathophyllinæ* and *Cystiphyllinæ*. The chief difference in the *Cystiphyllinæ* is that they have no distinct septal groove, and are wholly vesicular. As to *Calceola*, the inner surface of its operculum would give it a place near *Goniophyllum*, but it is removed from that place by its internal structure, which most closely resembles *Chonophyllum*, which, as far as known, also consists of the same thin and funnel-shaped strata. *Calceola* may then, at least, till further knowledge is gained, be placed between *Chonophyllum* and *Goniophyllum*. The series of the principal genera now mentioned would then be; *Chonophyllum, Calceola, Goniophyllum, Omphyma, Rhizophyllum, Cystiphyllum.*

There is reason to believe that there are other families besides the *Cyathophyllinæ*, in which some of the genera have been furnished with an operculum. In the oldest strata of the Isle of Gotland near Wisby, a fossil is occasionally found having, as it seems to me, the nature of an operculum of one of the *Zaphrentinæ*. It is irregularly triangular with rounded corners, generally very thin and almost concave on the outside (Plate XIV, Figs. 22 and 23). The nucleus is either central or lateral. On the interior surface is a triangular or circular area (Plate XIV. Fig. 23), around which the margins form an elevated border. This interior area is smooth, sometimes wavy, and crossed by from 8–9 filiform parallel and straight striæ, which

[1] *Rhizophyllum*, n. gen.; Testa semiconica, appendicibus radiciformibus instructa, structura interna cellulosa, calyx vesiculosus, in fundo fossa septali, septis perexiguis. Operculum nucleo centrali, areâ prætenui, in superficie interiori dente medio valido, foveâ ovali superaddita, dentibus lateralibus nullis. Species unica *R. Gotlandicum*, F. Roemer, in divisione suprema formationis Siluricæ in Gotlandia reperta. *Calceolæ*, or rather forms resembling *Calceolæ*, are by no means characteristic of the Devonian formation, as such also are found in the Lower Silurian strata of Western Gotland in the mainland of Sweden.

originate at the straightest margin. This must be considered as the cardinal margin and the others, where the striæ end as the lateral margin. Next within this border there is a depression with small pits between the striæ. This operculum belongs to a type quite different from that of the preceding fossils, being destitute of any prominent ridge in the middle, but it may, as I suppose, have been fixed to an animal of the same class. Its shape as well as its interior surface make it impossible to join it with any of the *Gasteropoda* which occur in the same stratum, and which are all *Holostomata*. Nor is there any tube of Annelids to which it might have belonged. The striæ on the inner surface are, in all probability, homologous with those of *Goniophyllum* situated on both sides of the median ridge. In the same stratum with this operculum there occurs only a species of *Hallia*, to which it in some degree corresponds. It has not yet been decided with certainty if there is a true connection between both, as the outlines of the calyx and the operculum are somewhat dissimilar. The area on the interior surface of the operculum within the border has, nevertheless, the same semicircular form at the mouth of the calyx, so that it is highly probable that they were connected and that the elevated border of the operculum projected outside the rim of the calyx when this was covered by the operculum. The shell of this *Hallia*, which, by reason of its exterior resemblance to *Calceola*, may be named *Hallia calceoloides* (Plate XIV. Figs. 19–21), has one surface flat and the other convex, the former, with a middle ridge consisting of two or three folds. Towards this ridge other smaller folds converge in a pinnate arrangement. When the shell has attained a length of about 25 millims its flat surface also becomes convex, and the form of the shell is cylindrical. On old specimens the outline of the calyx is circular, in younger ones semicircular. The shell is long and slender, sharply pointed, without any rootlets. In the interior of the calyx (Plate XIV. fig. 21) there is only one large septum of the first order, so characteristic of the genus *Hallia*. It is situated on the middle of the flat wall and reaches to the bottom of the calyx. It is surmounted on both sides by septa of a second order, which correspond with one another. They are 28 in number, with smaller ones between them, which only extend half as far as the wall. The septa continue, uninterrupted by tabulæ, &c., to the middle axis of the shell.

Many more specimens of *Z. rugosa* than those now mentioned have been provided with an operculum. The description and the figures of Guettard of a *Cyathophyllum*[1] with an operculum are sufficiently clear and evident not to be doubted any longer. It has already been mentioned that Professor Steenstrup observed a *Cyathophyllum mitratum* with a fragment of the operculum still *in situ*. He has also remarked that a small border noticeable around the interior rim of the calyx indicates, in many species, that they probably had an operculum.

I have been favoured with a kind communication from Thomas

[1] Mémoires, vol. iii., p. 510, plate 52.

Davidson, Esq., F.R.S., F.G.S., stating that he has seen a fossil from India (Carboniferous?) resembling in its exterior a *Cyathaxonia* with rootlets, and having a complete operculum still attached. Perhaps also the genus *Hypodema* may be considered as belonging to the operculiferous *Rugosa*. In some polished specimens, for which I am indebted to the liberality of Professor De Koninck, of Liège, I found a structure similar to that of the *Cystiphyllum*. I have also found in the older Silurian rocks of Wisby a fragment of an operculum which seems to belong to a shell with a circular calyx, possibly a *Cyathaxonia*. I have also found in a stratum of the middle group of Gotland (Upper Silurian) half of an operculum of the same type as that I consider to have belonged to *Hallia calceoloides*.

An apparent formation of opercula is not to be confounded with true opercula. It has been mentioned that many of the *Z. rugosa* during their growth strove to diminish and reduce the compass of their calyx. In several genera, as in *Campophyllum*, the calyx becomes more and more pointed and narrow towards the top. Sometimes this diminution of the shell has proceded thus: the calcareous substance was deposited horizontally and inwardly around the borders of the calyx in such a manner as almost to resemble an operculum; and it shows its origin when the calyx is not filled up in the centre, as from this opening, now and then, the diminished calyx again stretches out.

The chief results of these observations are as follows:—1. That *Goniophyllum pyramidale* is an undoubted *Zoantharia rugosa*, not only in all the parts of its shell, but also in having an operculum; that it coincides with the three species of the old genus *Calceola*, and that these are no longer to be numbered amongst the *Brachiopoda*, but must be considered *Rugosa*. 2. The *Rugosa* must be separated from the *Actinozoa*, or the true coral animals, as Agassiz and others have already asserted, on good grounds. 3. That they must form a class of their own in the great division of the Radiated animals.

They are hardly akin to the Hippurites with their aberrant calyx and peculiar structure, nor are they to be united with the *Serpulæ*, which, besides other differences, do not possess similar propagation by means of buds. Perhaps the researches of zoologists will confirm the supposition of Professor Agassiz, that they are related to the living *Lucernariæ*.[1]

Although the result of my observations have only a negative character, I think it best not to delay their publication, as they may

[1] Prof. Steenstrup joins the *Zoantharia tabulata* with the *Rugosa* and says that he has also specimens of them ("Calamopora" l.c.) with opercula *in situ*. Amongst the *Favositidæ* and similar forms so very common in the Isle of Gothland I never found true opercula, but tubes or cellulæ apparently having an operculum. On specimens of *Favosites Forbesi* (Pl. xiv. fig. 24) and also on others (as, for instance, a new *Fletcheria*) many tubes are frequently seen closed, or as it were, covered by a calcareous substance, consisting of concentrated lines of growth. This false operculum originated in quite a different manner from a true one. It is formed from borders of the tube growing towards its centrum, the central strata are the youngest. In many tubes, for instance, the centre of this apparent operculum is open. It is also impossible to discern any line of separation between the tube and the operculoid covering.

contribute in some degree towards the solution of the very difficult problem of the systematic place of the *Rugosa*. As early as 1859 I communicated my views to Prof. Lovén, Mr. Davidson, Prof. Roemer, and others. I soon afterwards made them public in a paper on the *Brachiopoda* of Gotland (1860). In 1861, I showed the lamented Dr. S. P. Woodward a suite of my specimens, expressing my results, and he announced in a paper in the "Geologist" for October, 1862, that he shared almost the same views.

The oldest seas, then, were almost totally without these animals,[1] although their power of building coral reefs is of such great importance in the seas of the present day. They were preceded in the Palæozoic periods by species which sometimes in the structure of their solid parts have an illusive analogy with them, but which, as Agassiz has shown in the *Tabulata*, and supposes also in the *Rugosa*, belong to an inferior class, rather allied to the *Hydrozoa*.

NOTICES OF MEMOIRS.

I.—Professor Daubreé on Meteorites and their Composition.

With Critical Notes, by M. Louis Sæmann, Memb. Inst., etc.

[*Continued from the August Number*, p. 366.]

IN a fourth chapter, entitled "Importance des roches magnésiennes du type péridot tant dans le globe terrestre que dans notre systéme planetaire," the author tries to reconcile the contradiction, so striking at first sight, that almost all meteorites present the same petrographical characters, whereas their terrestrial representatives are comparatively rare rocks. If the characteristic form and the state of aggregation of meteoric stones are entirely unknown amongst terrestrial rocks, it is worthy of remark that the chemical type, the mixture of Peridote and Bronzite, is found on points of the globe most widely separated, sometimes in the condition of true rock, like the Lherzolite of the Pyrenees and the Dunite of New Zealand, sometimes accidentally, so to speak, and in a fragmentary state, in basaltic rocks. These basalts might very well be the result of an absorption of the feldspathic rocks which the Peridotic rock has encountered on its upward passage, and which it has been able to re-fuse by its very elevated temperature. It remains to be examined,

[1] Only two Actinozoa (*Zoanth. perforata*), *Protaræa vetusta* and *P. Verneuili* are cited by M. Edwards as found in the Silurian strata of North America. *Palæocyclus porpita* is also often cited as an exception (Agassiz, Contrib. iii. p. 128. Morton. "Geologist," 1863, p. 466) and is placed amongst the *Fungidæ*. But its compact and solid shell, not at all perforated as in those whose septa alternate with the exterior folds ("costæ"), and do not continue outwards through the walls of the shell, give it a place in the *Z. rugosa* and in the vicinity of the genus *Heliophyllum*. As *Palæocyclus*, during its youngest state, has been attached to other bodies with its apex, it is evident that it cannot be considered as an operculum.